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# minimum tillage

for  
corn

Cooperative Extension Service  
South Dakota State University  
United States Department of Agriculture



# Minimum Tillage for Corn

By Lyle A. Derscheid, Extension agronomist, George R. Durland, Extension agricultural engineer, and Fred E. Shubeck, professor of plant science, Agricultural Experiment Station.

Each year South Dakota corn producers are caught in the cost-price squeeze. Since they have little control over prices, they are compelled to hold costs of production to a minimum. The use of minimum tillage helps attain this goal. This publication discusses several minimum tillage planting methods and some of their advantages and disadvantages.

## METHODS OF PLANTING

For years the conventional method of planting corn has been to plow with a moldboard plow, disk, harrow, and plant. The weeds were controlled by cultivating three times. In years past the weeder was used to supplement the row-crop cultivator. During recent years, a field cultivator is sometimes used instead of the disk and harrowing is sometimes omitted. Also the rotary hoe and flextine harrow have been used to replace the first row-crop cultivation.

Listing corn has been a common practice in several areas of South Dakota for years. The weeds were controlled with a row-crop cultivator.

Several systems of minimum tillage have been developed. They involve fewer operations than the conventional method.

### Strip Processing

Strip processing refers to any method where only a narrow strip of soil is thoroughly worked before planting. It is a quick, easy method of planting corn, much like hard ground listing.

**Zero Tillage.** This form of strip processing is sometimes called no till planting or coultter planting. The only tillage in the planting operation is with a fluted coultter about 2½ inches wide that stirs the soil in front of each planter unit. It is really a form of strip processing but so little of the soil is processed that it is called zero tillage. A major advantage of this method is low power requirement. A 40 hp. tractor can usually pull a 6-row planter.

This method is sometimes used in grass sod in conjunction with chemical sprays to kill all of the grass. The organic mulch from dead grass is effective in reducing erosion. Problems are phosphorus placement and cool early spring temperature. Obtaining good stands is sometimes difficult with this method.

**Till Planting.** This is another form of strip processing. Some operators run the tillage units deep in the soil and results are similar to hard ground listing. Deep cut roots sometimes cause cultivation problems. Till planters seem to work best when operated at a shallow depth on old corn row ridges. The wide sweep of a till-planter and shallow operation of the machine cuts off root clumps near the surface. This machine pushes these organic residues from over the row, allows the soil to warm up and gives good early spring growth of corn. It also decreases problems of cultivating.

Nebraska research shows the till-plant method reducing labor required for tillage 50% and soil loss 70% with no reduction in yield, compared to conventional production using plowing and planting in straight rows.

### Modified Rototilling

Some farmers use one of several machines with rotating knives to till the soil. This type of implement used ahead of the corn planter gives a one-trip operation for preparing the seedbed and planting. The same machine can be used as a row-crop cultivator. Some operators use two rotors to till a 15- to 17-inch band over the row, but most till the entire area. They then remove rotors over the row when cultivating between the rows. Equipment and operation costs are reduced by this method as well as eliminating compaction from repeated trips with a tractor. Power requirements for this implement are higher than for some of the other machines. It incorporates some residue into the soil and leaves some on the surface to form a mulch. The mulch helps reduce run-off, erosion, evaporation and increases water absorption. Although it was felt that these machines might damage soil structure and form a shallow plow-sole, some operators have used their equipment for as long as 6 years without creating these problems.

### Hard Ground Listing

Planting with a lister in unplowed ground prepares the seedbed and plants in one operation. It is a quick, easy way to plant corn. However, all weeds and weed seedlings must be controlled with tillage or





Chisel plow with curved chisels 3 inches wide and 22 inches long.



Residue from 50-bushel corn crop after chisel plowing.

spraying beforehand. You may have difficulty cultivating on rocky or soddy soil and you may have trouble controlling weeds or applying fertilizer.

**Cultivation problems.** If weeds are not controlled before planting, they will grow out of the side of the furrow or on the ridges between furrows. A lister cultivator (go-devil) set to throw soil away from the row the first cultivation generally does not control weeds adequately. By the second cultivation, weeds may be too large to be controlled when the soil is thrown into the row. Lister cultivators do not give good control of perennial weeds or volunteer alfalfa or grass. Implements equipped with 12- to 14-inch sweeps that run down the center of each ridge aid in controlling perennials and large annuals.

In rocky soils, lister shovels may slide around the rocks, leaving crooked rows that are difficult to cultivate. Hard ground listing in land that has been in alfalfa or perennial grass leaves clumps of sod that create a cultivation problem. Likewise, listing corn between last year's corn rows leaves stalks on the ridges that hamper cultivation. Plow alfalfa ground before listing and plow corn ground or chop stalks before

listing corn to prevent these problems. Fewer problems are encountered when corn is listed in small grain stubble. For the beginner, soybean land is a good place to start.

**Fertilizer problems.** Broadcast applications of fertilizer are pushed to the tops of the ridges by the moldboard of the lister. Phosphorus moves as little as 2 inches during an entire growing season and often does not reach the roots of corn planted 4 to 6 inches below the soil surface. In phosphorus deficient soils, some listed corn has suffered from lack of phosphorus until mid-July although fertilizer was broadcast on the surface. On soils that receive an annual application of phosphorus or on soils that have an adequate supply of phosphorus to a depth of 6 inches, this problem is less acute. It is also less important with nitrogen because nitrogen is more soluble and moves farther in the soil.

However, the maximum response to starter fertilizer is obtained when the fertilizer is placed 2 inches below and 2 inches to one side of the seed. Until recently, implement manufacturers have not provided a satisfactory attachment for listers for this type of fertilizer placement.

### Chisel Plowing

The chisel plow, equipped with curved chisels 22 to 30 inches long and 3 inches wide, is sometimes used in a fall tillage operation. This implement loosens the soil and covers about 30% of the crop residue even for average yields of corn. It appears to break up the plow sole and claypan, increase moisture absorption, and improve aeration while leaving a mulch and rough surface to control soil erosion and water runoff. To cover or anchor the crop residue in corn fields, corn stalks must be cut with a disk-type implement or a stalk chopper. The chopper is required in fields that produced high yields of corn. Some tillage may be required the following spring to level the seed-bed. This is a useful practice but costs more than most tillage operations other than moldboard plowing.

The long narrow chisels may be replaced by sweeps to form heavy-duty field cultivators. The implement will then loosen the soil and leave a mulch on the surface but it does not incorporate as much of the crop residue. Likewise straight chisel points can be used to loosen the soil without incorporating any appreciable amount of residue.

### Wheel Track Planting

Plowing with a moldboard plow is the only operation used for preparing the seedbed. All weeds and crop residue are turned under to keep trash from catching on the planter shoes. A regular corn planter seeds corn in tracks made by packer wheels or the wheels of the tractor pulling the planter. This method was tested by numerous farmers, but most have discontinued it.



## Plow Planting

Plowing and planting can be done in one operation by hitching a planter directly behind the plow. Weed and early tillage problems may be similar to those for wheel track planting. This method did not gain widespread usage primarily because most mold-board plows were not large enough to accommodate a 4-row planter, making it impossible to use a 4-row cultivator.

## Once-over Tillage

Several systems use variations and combinations of these basic methods, in one operation. They employ diggers, disks or packers hitched in tandem with planting units at the rear. Some do not reduce total tillage but reduce number of trips over the field; and are referred to as minimum tillage machines. Fewer trips over the field results in more efficient use of manpower and less soil compaction.

Perhaps the best way to evaluate these "once-over" methods would be to relate the specific operations performed and the tool used to the general principles involved in minimum tillage discussed below. However, these systems make it possible to better use the horsepower in some of the newer, larger tractors.



Stock chopper frequently needed before using minimum tillage on fields that produced high yields of corn and stalks.

## Comparison of Methods

Several methods of planting corn have been compared for yield and cost of seed bed preparation and planting.

**Yield comparisons.** Yields are given in Table 1 for four experiments in Brookings County over a 3-year period and for a 6-year experiment near Centerville.

Generally, plow planting and wheel-track planting produced yields comparable to those obtained by the conventional method. Listing and strip processing gave inferior yields (especially at Brookings) primarily because of poor weed control. Disking before

planting probably would have helped on this problem. Listing was not inferior in 1961 when an overall pre-emergence spray was used for weed control.

**Cost comparisons.** Cost of planting corn generally increases every year or so. However, it increases for all methods. It is estimated that plow-planting and wheel-track planting cost about 60% as much as the conventional method while hard ground listing and strip processing cost about 40% as much. Disking before listing to control weeds that have emerged increases the cost of listing to about 60% and band spraying pre-emergence to control weeds in strip processing raises the cost of this method to about 80% of that of the conventional method.

Table 1. Bushels per acre of corn planted by several methods for 3 years (1959-61) in Brookings County and for 6 years (1962-67) near Centerville.

Planting method	Brookings		S.E. Experiment Farm	
	After corn 1959	After grain 1959-61	Preplant tillage	Yield 1962-67
Conventional	29	51	Spring plowing	93*
Conventional	43*	63*	Fall plowing	93*
Wheel track	32	55	-----	-----
Wheel track	40*	65*	-----	91*
Plow planting	-----	60	-----	-----
Plow planting	-----	64*	-----	92*
Listing	44	38	None	87*
Listing	47*	48	Fall plowing	88*
Strip processing	18	12†	Noble blading	89*
Strip processing	31*	17*	-----	-----

\*2.4 lb/A active ingredient per acre on area treated with simazine (1959-60) or atrazine (1961-67) in 13-inch bands over the row.

†Yield from 1959 experiment where conventional method produced 24.0 bu/A on unsprayed plot and 32.3 bu/A where weeds were controlled.

## ADVANTAGES AND DISADVANTAGES

Several soil and moisture factors are affected by tillage.

### Water Infiltration

Minimum tillage methods that maintain a mulch of organic material on the surface usually have better rainfall infiltration and less runoff. This becomes more pronounced as percent slope increases.

After the soil in conventionally prepared seedbeds has been firmed by disking, harrowing, and planting, rate of infiltration has been reduced by one half or more, compared to loose plowing. Methods like wheel track planting encourage water absorption because plowed soil is left loose and unpacked between rows. Chisel plowing also loosens the soil and increases water infiltration. Any method that ridges the soil and helps detain water will help to increase infiltration.

### Soil Erosion

Soil erosion is closely related to infiltration. A loose open soil will have more infiltration with less runoff and erosion. Therefore, tillage methods that





**Modified rototiller planting corn.**

promote rapid infiltration will generally have less erosion. Those methods that maintain a mulch on the surface are very effective in reducing both wind and water erosion. Generally speaking, those methods that involve fewer tillage operations usually leave a soil structure that is more resistant to erosion. By the time a soil is disked, plowed, harrowed, and cultivated three times, soil structure is broken down to small units which are easily removed by wind or water.

## **Water Evaporation**

In the early part of the growing season before soil is protected by a leafy canopy, evaporation accounts for a high percentage of total soil water loss. An organic mulch reduces water loss during this vulnerable period. Therefore, minimum tillage, that maintains an organic mulch on the soil surface, reduces the quantity of water wasted by evaporation. Mulches are generally more effective than tillage alone. Most tillage that leaves a loose soil allows faster rainfall infiltration, also permits greater evaporation. Few tillage methods facilitate movement of water one way but not the other. Reduced evaporation usually results in higher soil temperature.

Total water loss from an acre of corn is a function of total heat, winds and relative humidity at ground level. Corn plants reduce wind velocity and combinations of narrow row spacing and plant populations have been successful in reducing soil temperature, after leaf canopy has developed. If plants can be arranged in the field to prevent some of the evaporation force from reaching the soil, it is reasonable to assume that the water loss would be shifted so that more loss would occur through transpiration than by evaporation. Water that moves through plants in the transpiration stream benefits the plants in several ways, whereas, water lost by evaporation is wasted.

## **Soil Temperature**

One major disadvantage of using an organic mulch is that it depresses soil temperature  $2^{\circ}$  to  $12^{\circ}$  at seed depth and slows early growth of corn. Cooler temperatures inhibit recovery of phosphorus and potassium by plants. Breakdown of organic matter and release of its nutrients by soil microorganisms is slowed. Consequently less of the original nitrogen and phosphorus stored in soil organic matter is made available to plants.

Several minimum tillage methods leave plant residues on the soil surface to increase rate of water infiltration and reduce erosion. The soil temperature problem due to organic mulches becomes more acute in the northern corn growing areas of South Dakota and on higher elevations of the Prairie and Missouri Coteaus.

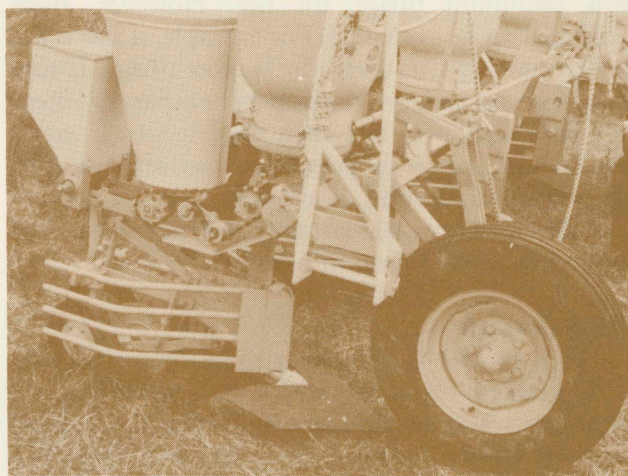
Detrimental effects of cool temperatures due to mulches can be partially overcome by using starter or pop-up fertilizer. In extreme cases, this technique is not sufficient to overcome slow early growth on mulched soils.

## **Soil Compaction and Aeration**

Seedbed preparation with little or no tillage does not loosen the soil or reduce compaction. Plowing is the best way of reducing density of surface soils. As soil compaction increases, above 1.4 grams per cubic centimeter, root growth is limited more and more. Dense and compact soils may also restrict root growth due to insufficient exchange of soil air with air above ground. Oxygen content of soil air decreases and carbon dioxide increases until root growth is restricted.

## **Soil Structure**

Size of soil structural aggregates usually increase as content of silt and clay increase. Moisture content at time of tillage also effects size and stability of aggregates. Large aggregates help reduce erosion and increase infiltration but do not provide the best seed-



**One of several machines used for strip process method.**



soil contact for rapid germination. Therefore a combination of aggregate sizes is more desirable than large quantities in either size extreme.

Conventional corn tillage methods are notorious for breaking down soil structure into small units which are easily eroded.

For each tillage trip over the field eliminated through minimum tillage methods, soil structure remains one step higher in the breakdown process. From a soil structural standpoint, a system with an intermediate number of tillage operations is most desirable.

### **Adaptation to Soil Types**

Those minimum tillage methods that maintain a protective cover of organic residues on the soil surface are especially advantageous on easily-eroded sandy or silty soils, and on steep slopes.

Glacial till soils that have large rocks exposed at the surface are difficult to plant using minimum tillage methods such as hard ground listing and till planting.

Most researchers agree that heavy textured, poorly aerated, imperfectly drained soils need some tillage in the fall when they are dry enough to be tilled. A poor job of tillage in the fall can be turned into a relatively good seedbed in the spring by the freezing and thawing action during the winter. Minimum tillage methods that are close to zero tillage are not especially adapted to these soils.

### **PROBLEMS**

The use of "no plow" minimum tillage systems sometimes creates problems not encountered when the moldboard plow is used to help prepare the seedbed.

With some minimum tillage methods, soils are cloddy, root clumps are strewn over the surface and crop residue is present. Some operators run a cultivator into this situation just once and are through with minimum tillage for life. However, these problems can be overcome. For example, if soil is too cloddy, use a system with a little more tillage. If root clumps are present, run the implement that digs them up a little shallower or switch implements. If excessive organic matter is present on surface, use disk type cultivators instead of shovels.

Other practices sometimes need to be handled differently with minimum tillage.

### **Weed Control**

Weed control is frequently the most serious and costly problem associated with minimum tillage. As the intensiveness of cultivation is reduced, the need for weed chemicals is increased. In effect, there is a substitution of chemicals for tillage and this substitution may occur from zero to nearly 100%. Unless

fields are unusually free of weeds, it would be unwise to try any form of minimum tillage without at least a band application of herbicide over the row.

Herbicides that must be applied preplant and incorporated are not very useful in any minimum tillage system. Minimum tillage does not work them into the soil. Annual weeds present at planting can be destroyed with foliage sprays and those weeds that germinate or regrow after planting can generally be controlled with herbicides that are applied preemergence and do not require mechanical incorporation. However, the effectiveness of preemergence applications is influenced by weather. If the herbicide fails, rescue work with the cultivator may be needed.

Noxious weeds give special problems characteristic to each individual weed species. With noxious weeds and other perennial weeds, it's a great help to begin with the initial set-back to weed growth afforded by the moldboard plow.

### **Fertilizer Placement**

Results from different states are not all in agreement, especially in regard to placement of phosphorus. Phosphorus moves very little from the point of application during a year's time. When phosphorus is broadcast on the surface and little or no tillage performed afterward, the phosphorus remains at or very near the surface for years. When soils of low phosphorus supplying ability begin to dry, uptake and recovery of this element is sharply curtailed when most of it is in the top inch or two below the soil surface.

This has not been a severe problem in some corn belt states where July and August rainfall averages an inch or more per week. But in South Dakota where we may not receive an inch of rain in an entire month, phosphorus placement may become a problem. One way to overcome this is to plow every third or fourth year to move the surface concentration of phosphorus down deeper in the soil profile. Another way is to band the phosphorus 4 to 5 inches deep at time of planting.

Problems with potassium placement are somewhat similar to phosphorus but not quite so severe because potassium is slightly more mobile in the soil.

Nitrogen moves readily with downward movement of soil moisture, but to be on the safe side it is best to put the nitrogen in the root zone. If applied early there is a greater chance of sufficient rainfall to carry nitrogen down to root zone before plants reach their peak in daily requirements.

### **Insect Control**

Problems of both incidence and control measures of certain insects will be compounded as tillage is reduced. This pertains to soil insects such as white grub,



cutworm, wire worm and seed corn maggot. In addition, slugs may be a problem in soils covered by an organic mulch.

These pests can be controlled by broadcasting and incorporating the proper insecticides. With some minimum tillage methods, soil incorporation of an overall application is difficult or impossible. Band applications are usually not incorporated very thoroughly. The value of band or row applications for these insects has simply not been sufficiently investigated to evaluate their effectiveness.

### Obtaining Adequate Stands

Generally speaking, it is easier to get adequate stands with conventional methods than with minimum tillage methods. Adequate stands can be obtained with less tillage but it takes more care and effort. Sometimes a simple adjustment like putting more pressure on the packer wheel is sufficient. A covering knife or disk may be needed to bring in a little more soil in front of the packer wheel. More frequent adjustments on depth of furrow opener for different soil densities and moisture levels will sometimes help. Zero tillage methods and those with the least amount of tillage that leave soil lumpy will probably give the most trouble.

### ECONOMICS OF MINIMUM TILLAGE

There have been no consistent yield increases from minimum tillage methods over conventional methods in South Dakota research results. The economical advantage comes from savings in operational costs and savings in time required to perform the total operation.

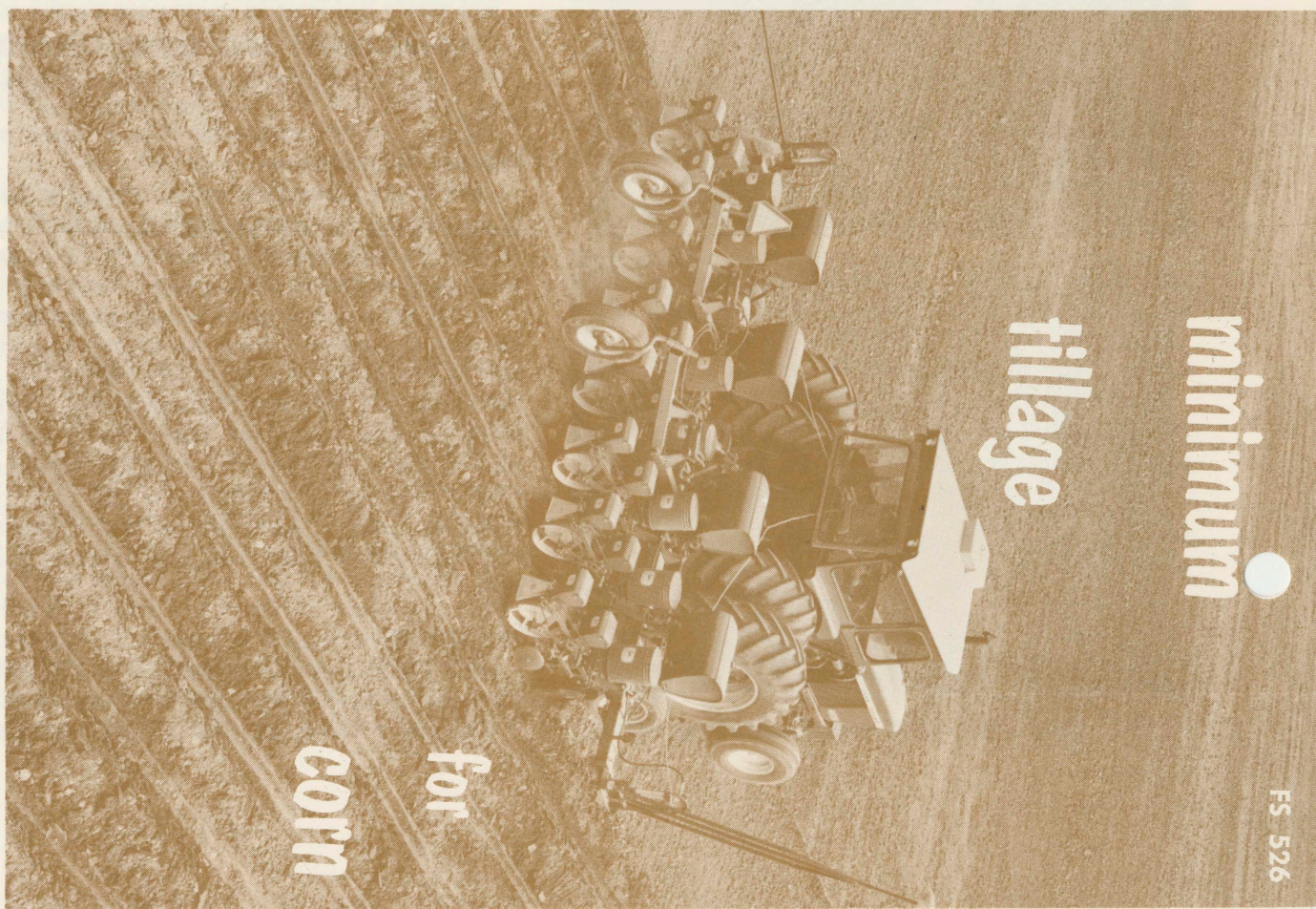
For farms without a weed problem this represents a decided advantage in favor of systems with reduced tillage. However, on most farms the greater the reduction in tillage the greater is the need for chemicals to control weeds. Some planting systems have special, built-in advantages in this regard. For example, in wheel track planting where a band of herbicides is placed preemergence over the row, weeds are effectively controlled in the row by chemicals. In the loose plowing between rows the weeds are slow to emerge and do not create an early problem. This eliminates the first one or two cultivations that are slow and expensive.

#### Secure These Fact Sheets for More Information on Corn Production:

- Fertilizing Corn
- Weed Control in Corn
- Corn Rootworm Control
- Control of European Corn Borer
- A New Corn Maturity Rating
- Diseases of Corn (smut, ear rot, stalk rot and leaf blight)
- Drying Corn
- Planting Corn in South Dakota.

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